NASA Headquarters Perspective on MODIS and Suomi NPP

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National Aeronautics and Space Administration HQ
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15-19 October 2018

Terra/Aqua Data Product Transition to the Senior Review

- **2013 - A.46 - Terra and Aqua Algorithms – Existing Data Products (32 proposals) moved to the Senior Review in 2017 and selections split between Terra and Aqua (now managed by Kurt Thome (Terra) and Claire Parkinson (Aqua) – 27 proposals total**
  - **Five instruments on Terra (ASTER, CERES, MISR, MODIS, and MOPITT) plus four on Aqua (AIRS, AMSU, CERES, and MODIS) collectively contributed to 81 calibrated & validated core data products**
  - **SR included MODIS, AIRS/AMSU products, not instruments no longer functioning or PI-led with separate program elements/science teams**
  - **Senior Review Total Selected budget profile of $3.95M / $4.4M / $4.7M ($13.05M/3 years total)**
  - **Lessons learned: iterated guidance letter with teams and planning telecons very helpful, dedicated panelists for review**
  - **Note: will Suomi NPP be included in the next Senior Review? If so, then are any of the algorithms funded in 2017 that will be ready for Senior Review transition?**

2016/2017 Senior Review – Terra – 21 proposals

1. Steven Ackerman, Maintenance of Cloud Mask, Cloud Top Pressure, Cloud Top Phase, Atmospheric Profiles and Calibration from MODIS (University of Wisconsin-Madison)
2. William Balch, Maintenance and refinement of the MODIS algorithm for particulate inorganic carbon (Bigelow Laboratory for Ocean Sciences)
3. Jeffrey Czapla-Myers, Validation of Aqua and Terra surface reflectance products using the automated Radiometric Calibration Test Site (RadCaTS) (University of Arizona)
4. Kamel Didan, Maintaining the Terra and Aqua MODIS Vegetation Index Product Record (University of Arizona)
5. Bryan Franz, Maintenance and Quality Assessment of Remote Sensing Reflectance, Chlorophyll, and Diffuse Attenuation Products to Support MODIS Ocean Color Science (NASA Goddard Space Flight Center)
6. Robert Frouin, Maintenance to the MODIS Standard Ocean PAR Product (Scripps Institution of Oceanography, UCSD)
7. Louis Giglio, MODIS Global Active Fire and Burned Area Product Maintenance (University of Maryland)
8. Dorothy Hall, Maintenance of the MODIS Snow and Ice Product Suites (NASA Goddard Space Flight Center)
9. Simon Hook, In Flight Validation of ASTER and MODIS Mid and Thermal Infrared Data (NASA Jet Propulsion Laboratory)
10. N. Christina Hsu, Maintaining MODIS Deep Blue Products for Terra and Aqua (NASA Goddard Space Flight Center)
11. Robert Levy, Maintenance of the MODIS dark target aerosol algorithm and the MOD02/MYD04 Aerosol Products (NASA Goddard Space Flight Center)
12. Antonio Mannino, Terra and Aqua MODIS Ocean Color Chlorophyll-a Algorithm Maintenance Support with Quality-Assured HPLC Pigment Analysis (NASA Goddard Space Flight Center)
13. Peter Minnett, Sea-Surface Temperature from MODIS on Aqua (University of Miami, RSMAS)
14. Ranga Myneni, Maintenance and Assessment of Terra and Aqua MODIS LAI and FPAR Products (Boston University)
15. Steven Platnick, Maintenance of Cloud Optical and Microphysical Properties and Gridded Atmosphere Products from MODIS (NASA Goddard Space Flight Center)
16. Steven Running, Providing Continuity for the MODIS MOD 17 Land Gross Primary Production, Net Primary Production and MOD 16 Evaporation Datasets on Terra and Aqua (University of Montana)
17. Crystal Schaaf, Maintenance of the MODIS Albedo, Nadir Reflectance and Surface Anisotropy Products (Univ. of Massachusetts-Boston)
18. David Siegel, Plumes and Blooms MODIS Algorithm Maintenance (University of California – Santa Barbara)
19. John Townshend, Vegetation Continuous Fields Collection 6 Refinements (University of Maryland)
20. Eric Vermote, Maintenance of the MODIS Aqua/Terra surface reflectance product suite (NASA Goddard Space Flight Center)
21. Robert Wright, MODVOLC Algorithm: Near-Real-Time Detection, Monitoring and Quantification of Global Volcanic Eruptions Using Terra and Aqua MODIS (University of Hawaii at Manoa)

2016/2017 Senior Review – Aqua – 26 proposals

1. Steven Ackerman, Maintenance of Cloud Mask, Cloud Top Pressure, Cloud Top Phase, Atmospheric Profiles and Calibration from MODIS (University of Wisconsin-Madison)
2. William Balch, Maintenance and refinement of the MODIS algorithm for particulate inorganic carbon (Bigelow Laboratory for Ocean Sciences)
3. William Blackwell, Improved Algorithm Initialization for AIRS/AMSU and AIRS-only Products (MIT Lincoln Laboratory)
4. Jeffrey Czapla-Myers, Validation of Aqua and Terra surface reflectance products using the automated Radiometric Calibration Test Site (RadCaTS) (University of Arizona)
5. Kamel Didan, Maintaining the Terra and Aqua MODIS Vegetation Index Product Record (University of Arizona)
6. Bryan Franz, Maintenance and Quality Assessment of Remote Sensing Reflectance, Chlorophyll, and Diffuse Attenuation Products to Support MODIS Ocean Color Science (NASA Goddard Space Flight Center)
7. Robert Frouin, Maintenance to the MODIS Standard Ocean PAR Product (Scripps Institution of Oceanography, UCSD)
8. Louis Giglio, MODIS Global Active Fire and Burned Area Product Maintenance (University of Maryland)
9. Dorothy Hall, Maintenance of the MODIS Snow and Ice Product Suites (NASA Goddard Space Flight Center)
10. Simon Hook, In Flight Validation of ASTER and MODIS Mid and Thermal Infrared Data (NASA Jet Propulsion Laboratory)
11. N. Christina Hsu, Maintaining MODIS Deep Blue Products for Terra and Aqua (NASA Goddard Space Flight Center)
12. Robert Levy, Maintenance of the MODIS dark target aerosol algorithm and the MOD02/MYD04 Aerosol Products (NASA Goddard Space Flight Center)
13. Antonio Mannino, Terra and Aqua MODIS Ocean Color Chlorophyll-a Algorithm Maintenance Support with Quality-Assured HPLC Pigment Analysis (NASA Goddard Space Flight Center)
14. Peter Minnett, Sea-Surface Temperature from MODIS on Aqua (University of Miami, RSMAS)
15. Ranga Myneni, Maintenance and Assessment of Terra and Aqua MODIS LAI and FPAR Products (Boston University)
16. Norman Nelson, Providing Continuity for the MODIS MOD 17 Land Gross Primary Production, Net Primary Production and MOD 16 Evaporation Datasets on Terra and Aqua (University of California – Santa Barbara)
17. Edward Olsen, Maintenance and Minor Refinement of AIRS CO2 Product (NASA Jet Propulsion Laboratory)
18. Steven Platnick, Maintenance of Cloud Optical and Microphysical Properties and Gridded Atmosphere Products from MODIS (NASA Goddard Space Flight Center)
19. Steven Running, Providing Continuity for the MODIS MOD 17 Land Gross Primary Production, Net Primary Production and MOD 16 Evaporation Datasets on Terra and Aqua" (University of Montana)
20. Crystal Schaaf, Maintenance of the MODIS Albedo, Nadir Reflectance and Surface Anisotropy Products (University of Massachusetts-Boston)
21. David Siegel, Plumes and Blooms MODIS Algorithm Maintenance (University of California – Santa Barbara)
22. Lawrence Strow, AIRS Forward Model Improvements (University of Maryland Baltimore County)
23. Joel Susskind, Upgrade and Maintenance of the AIRS Science Team Version-6 Retrieval algorithm (NASA Goddard Space Flight Center)
24. Eric Vermote, Maintenance of the MODIS Aqua/Terra surface reflectance product suite (NASA Goddard Space Flight Center)
25. Toby Westberry, Maintenance and Ongoing Evaluation of the Aqua MODIS Chlorophyll Fluorescence Line Height (FLH) Product (Oregon State University)
26. Robert Wright, MODVOLC Algorithm: Near-Real-Time Detection, Monitoring and Quantification of Global Volcanic Eruptions Using Terra and Aqua MODIS (University of Hawaii at Manoa)

ROSES 2017 A.37 The Science of Terra, Aqua, and Suomi NPP Recompete

- **A.37 – The Science of Terra, Aqua, and Suomi NPP - recompetition in ROSES 2017 – merged Terra, Aqua, and Suomi NPP with a focus on new algorithms and data products, EOS continuity products, disciplinary and Earth System Science**
  - **2.1 Science Data Analysis**
  - **2.1.1 Multiplatform and Sensor Data Fusion**
  - **2.2 Algorithms – New Data Products**
  - **2.3 Algorithms for Terra and Aqua Existing Data Product and Suomi NPP EOS Continuity Data Product Creation and Refinement - direction to 2.1**
  - **2.4 Real- or Near-Real-Time Data Algorithms**
  - **2.5 NASA Suomi NPP Science Team Leader and Terra, Aqua, Suomi NPP Discipline Leads**
  - **Proposals Recommended: 68/230 ($34.96M/3 yrs selected - $11.5 /11.7 / 11.75M) – 2017 release to reduce uncosted carryover**

Suomi NPP: EOS Standard Products (Land)

EOS Standard Land Data Products Recommended for Suomi NPP:

- Surface Reflectance (Vermote - #26; Next Generation: Lyapustin - # 116)
- Snow Cover (Riggs- # 122)
- Land Surface Phenology and Vegetation Indices (Zhang, X - # 118)
- Fire and Thermal Anomalies (Schroeder - # 57)
- Sea Ice Cover and Ice Surface Temperature (Riggs- # 122)
- BRDF / Albedo (Schaaf - # 172)
- Incident downward shortwave radiation and PAR (Wang - #76)
- Leaf Area Index (LAI) and Fraction Absorbed Photosynthetically Active Radiation (FPAR) (No Selection)
- Land Surface Temperature and Emissivity (No Selection)
- Vegetation Continuous Fields (No Selection)

Suomi NPP: EOS Standard Products (Ocean)

EOS Standard Ocean Data Products for Suomi NPP:

- Sea Surface Temperature (Minnett - # 164; Next Generation: Koner- # 178)
- Aerosol Angstrom Exponent (Franz - #65; Next Generation – Knobelspiesse - # 144)
- Aerosol Optical Thickness (Franz - #65; Next Generation – Knobelspiesse - # 144)
- Subsurface Chlorophyll *a* Concentration (Gregg - # 17; Franz- # 65)
- Diffuse attenuation at 490 nm (Franz - # 65)
- Photosynthetically Available Radiation (Frouin - # 61)
- Particulate Inorganic Carbon (No Selection)
- Particulate Organic Carbon (Stramski - # 63)
- Remote Sensing Reflectance (Franz - # 65)

Suomi NPP: EOS Standard Products (Atmosphere, from MODIS)

EOS Atmosphere Data Products (from MODIS) recommended for Suomi NPP:

- Aerosol Product (Hsu - # 20)
- Total Precipitable Water (Water Vapor) (No Selection)
- Cloud Product (Platnick - #120; Yang - # 12)
- Atmosphere Gridded Product (No Selection)
- Cloud Mask (Platnick - # 120)

Suomi NPP: EOS Standard Products (Atmosphere from OMI/MLS)

EOS Standard Atmosphere Data Products (from Aura's OMI and MLS) recommended for Suomi NPP:

- Total Column Ozone (McPeters - #173)
- Ozone Concentration Vertical Profiles (McPeters - #173)
- Aerosol Concentration Vertical profiles (Taha - #59)
- NO_2 Total Column (Li- #117)* change from Yang.
- Sulfur Dioxide Total Column (Li - #117) *change from Yang.
- Aerosols Total Column (Hsu - #15)

Suomi NPP: EOS Standard Products (from Sounder)

EOS Standard Sounder Data Products recommended for Suomi NPP:

- Atmospheric Temperature (vertical profiles) (Barnett - # 13)
- Atmospheric Moisture (vertical water vapor profiles, total precipitable water, total cloud liquid water) (Barnett - # 13)
- Atmospheric Pressure Vertical Profiles (No Selection)
- Surface Temperature (Barnett - # 13)
- Cloud Properties (fractional cover, cloud top temperature, cloud top height) (Barnett - # 13)

Suomi NPP: Standard Products Not Selected

- Particulate Inorganic Carbon
- Net Primary Production (Ocean)
- Leaf Area Index (LAI) and Fraction Absorbed Photosynthetically Active Radiation (FPAR) – LAI (Myneni) covered by TE for one year
- Land Surface Temperature and Emissivity – LST and emissivity (Hulley) covered for one year to complete VIIRS LST and emissivity algorithm work; LST (Hook) to support VIIRS cal-val in mid-IR and thermal
- Vegetation Continuous Fields
- Burned Area - TE funded (Giglio) three years to complete VIIRS BA algorithm
- Atmospheric Pressure Vertical Profiles
- Total Precipitable Water (Water Vapor)
- Atmosphere Gridded Product

2.5 NASA Suomi NPP Science Team Leader and Terra, Aqua, Suomi NPP Discipline Leads

- Discipline Leads - Land, Ocean, Atmosphere, Sounder, and Ozone
- Suomi NPP - ATMS, CERES (not included), CrIS, OMPS, and VIIRS - **Bryan Baum** (University of Wisconsin) – Science Team Leader
- Terra and Aqua Data include: MODIS (T, A), ASTER (T), MOPITT (T), MISR (T), CERES (T, A), AIRS/AMSU-A (A), AMSR-E (A), and EOS Direct Broadcast sites

- NASA Terra, Aqua, Suomi NPP Discipline Leads – coordinate/represent "disciplines":
  - Land: MODIS and VIIRS Land Products and Applications – **Chris Justice w/Miguel Román**
  - Ocean: MODIS and VIIRS Ocean Products and Applications - **Bryan Franz (MODIS) and Kevin Turpie (VIIRS)**
  - Atmosphere: MODIS and VIIRS Atmosphere Products and Applications - **Steve Platnick and Steve Ackerman**
  - Sounder: Sounder (ATMS and CrIS) Products and Applications - **Chris Barnet**
  - Ozone: Ozone (OMPS) Products and Applications - **Rich McPeters (OMPS)**

A.37 Science of Terra, Aqua, and Suomi NPP - Issues

- PI confusion as to whether they were working on a standard product or other product (Section 6.0 of solicitation) – new "ATBD" review process
- Process by which a "new" or "provisional" approach/algorithm is transitioned to a standard data product (ATBD review)
- PI understanding of the difference between data product and algorithm
- Definition of Category 1 vs. Category 2 for each proposal, especially when the PI did not declare (requirement) – key for understanding SIPS resources needed, if any, to augment
- 2.7 Science Investigator-led Processing Systems (SIPS) – not competed – amended 7 July 2017
  - To support accurate estimation of data system capacity to produce and archive products selected through this solicitation, all proposers must categorize their proposal into one of the following types:

1. Proposals that continue the generation of existing products.
2. Proposals that seek to develop new products or substantially modify existing products.
   - For Category 1 proposals, PIs must merely state that it is a Category 1 proposal.
   - For Category 2 proposals PIs must, in the NSPIRES cover page text boxes for the data management plan, explicitly state "This is a Category 2 proposal" and provide all pertinent information needed to estimate increased production capacity - for example, daily archive volume, processing cycles, ancillary data and software. Terra, Aqua, and Suomi NPP PIs of selected proposals will work with NASA's Earth Science Data System Program and Earth Science Data and Information System (ESDIS) Project to develop accurate production and archival sizing estimates. PIs on selected proposals will then work with ESDIS and the SIPS to implement the proposed products.

A.37 Science of Terra, Aqua, and Suomi NPP - Issues

- 2.1.1 – 38/56 proposals found NR to the 2.1.1 solicitation program element, 31 were reclassified by program managers prior to panel reviews to disciplinary panels; 7 additional proposals were deemed NR during the 2.1.1 panel review referred to the disciplinary panels
- Confusion by community regarding the 2.1.1. solicitation (multi-sensor, multi-platform; interdisciplinary). Potential solution is to have a very short, focused solicitation with the main focus on science/research, and a very small, walled off amount of funding for a subelement on algorithm tweaking. **Algorithm developments for Standard Products may be important, but they do not generate much excitement on the part of reviewers or program managers.**
- Some confusion about definition of what is a viable science question in this context. Proposals wished to "tweak" algorithms with no justification for the science targeted (build it and they will come). Confusion about who/what is (should be) funding near real time efforts
- Requirement for error and uncertainty analysis was largely unmet
- The solicitation was complex, having several rather different components, each with its own sets of requirements.

Data Product Development and Documentation

Standard, Evaluation, and Test Products

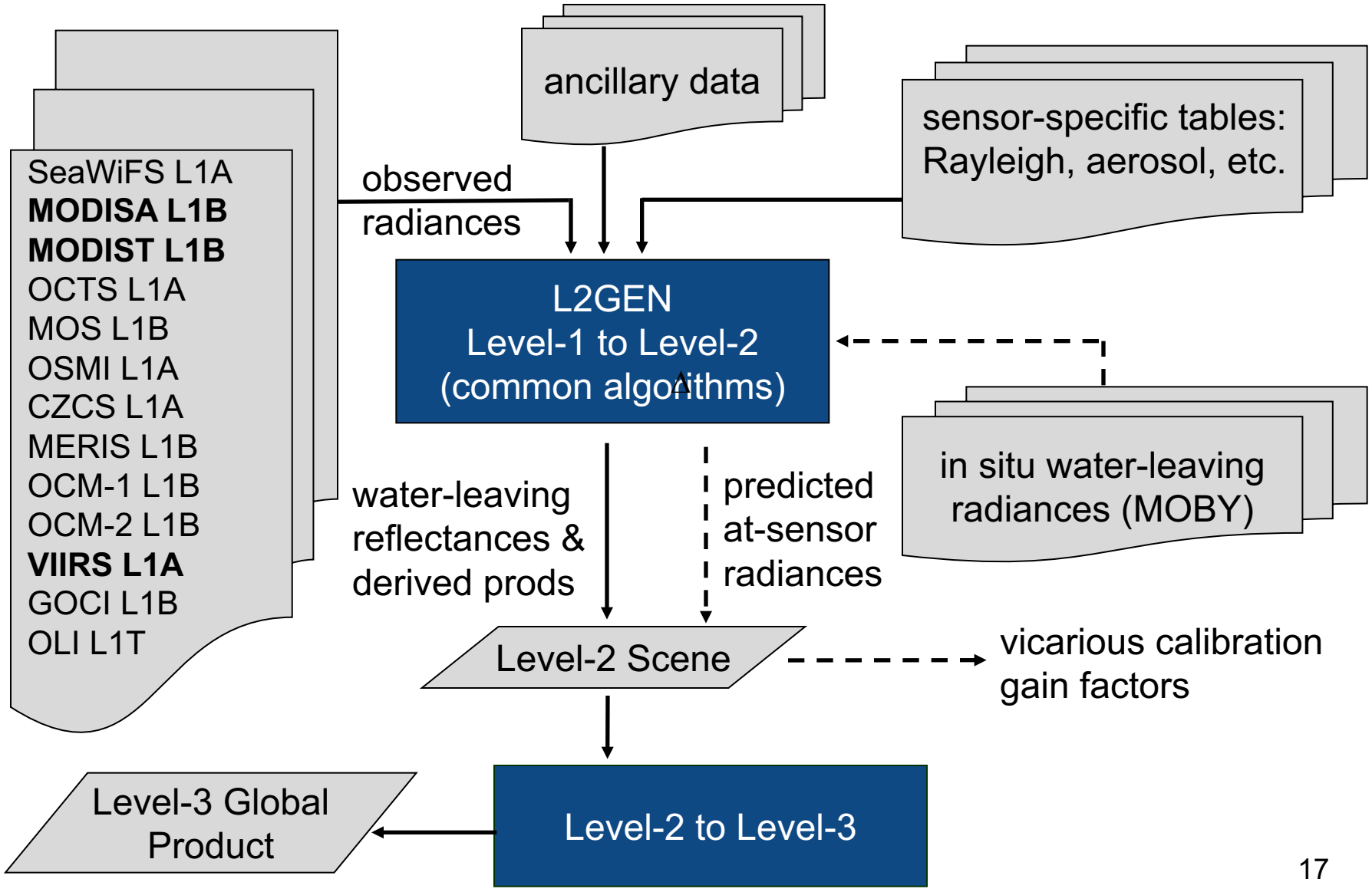
- a **standard product** is one that the SIPS is committed to maintain, and the DAAC is committed to archive and distribute, at the ultimate discretion of Program Management

- an **evaluation product** is one that the SIPS/DAAC may produce and distribute, if resources allow, to support community assessment of a new product or alternative product algorithm

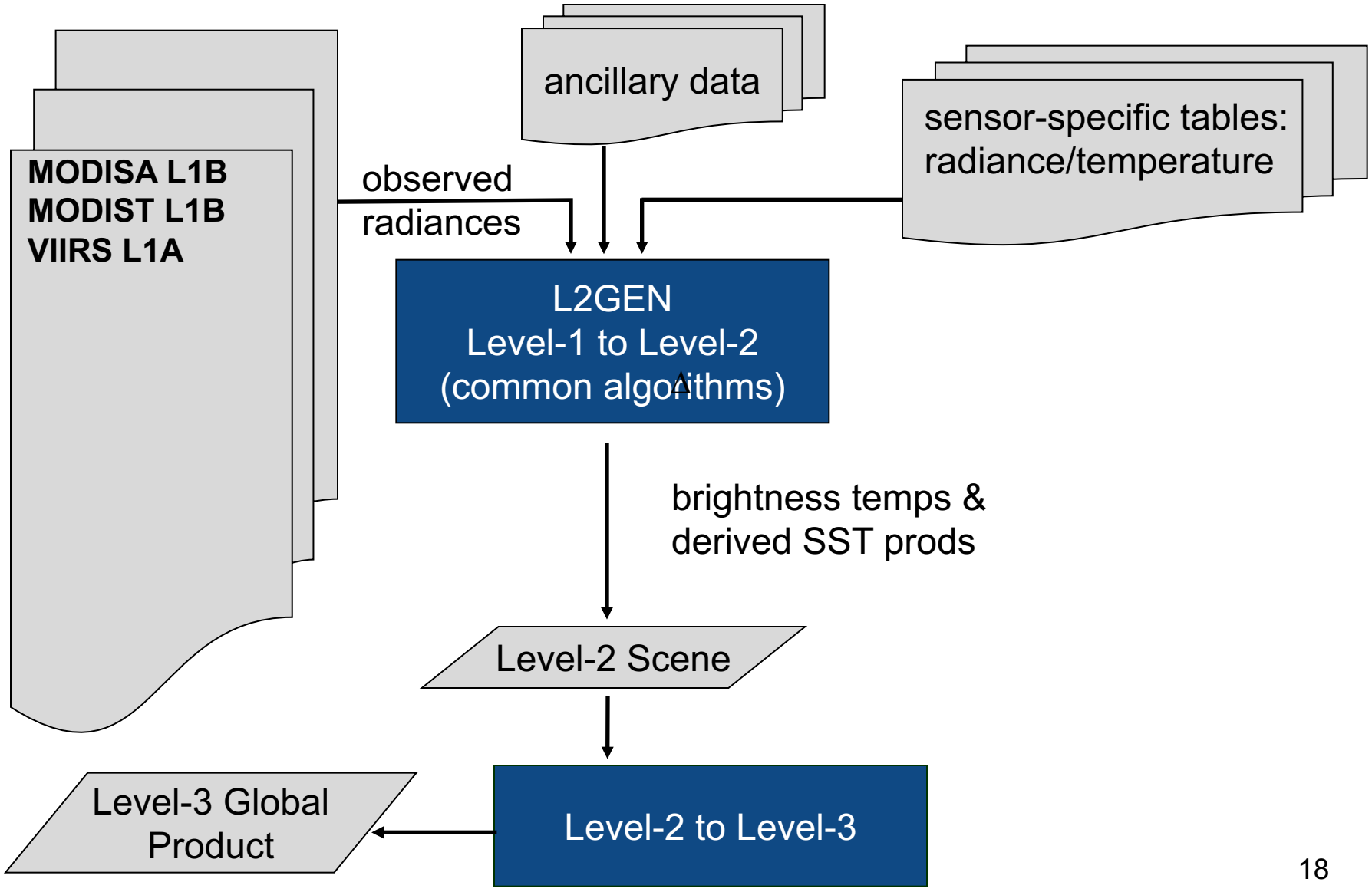
- a **test product** is one that the SIPS may produce to support the algorithm PI in implementation verification and product testing

in practice, OC standard products are made at Level-2 and Level-3, while eval products are made only at Level-3 (usually from Level-3 R_{rs} dailies).

OC Implementation
NASA Standard Processing Code



SST Implementation
NASA Standard Processing Code



Product Documentation

- MODIS has historically required that every standard product have associated with it an Algorithm Theoretical Basis Document (ATBD)
- The original MODIS ATBDs are extremely out of date and in many cases they are not relevant to current standard products
- This is largely due to the fact that the MODIS processing was awarded to the NASA OBPG in 2004 with the mandate to adopt the SeaWiFS heritage processing, as documented in SeaWiFS TMs
- It is also the case that the ocean algorithms are predominantly sensor-independent, evolved from broad community contributions
- To satisfy NASA Program Management and better serve the research community, we need to establish a new set of product documentation for the current standard product suite of MODIS & VIIRS, and maintain that level of documentation going forward
- To that end, Ocean SIPS is developing a set of online documents that can be easily updated and will include dynamic links to ensure that implementation and validation information remains current

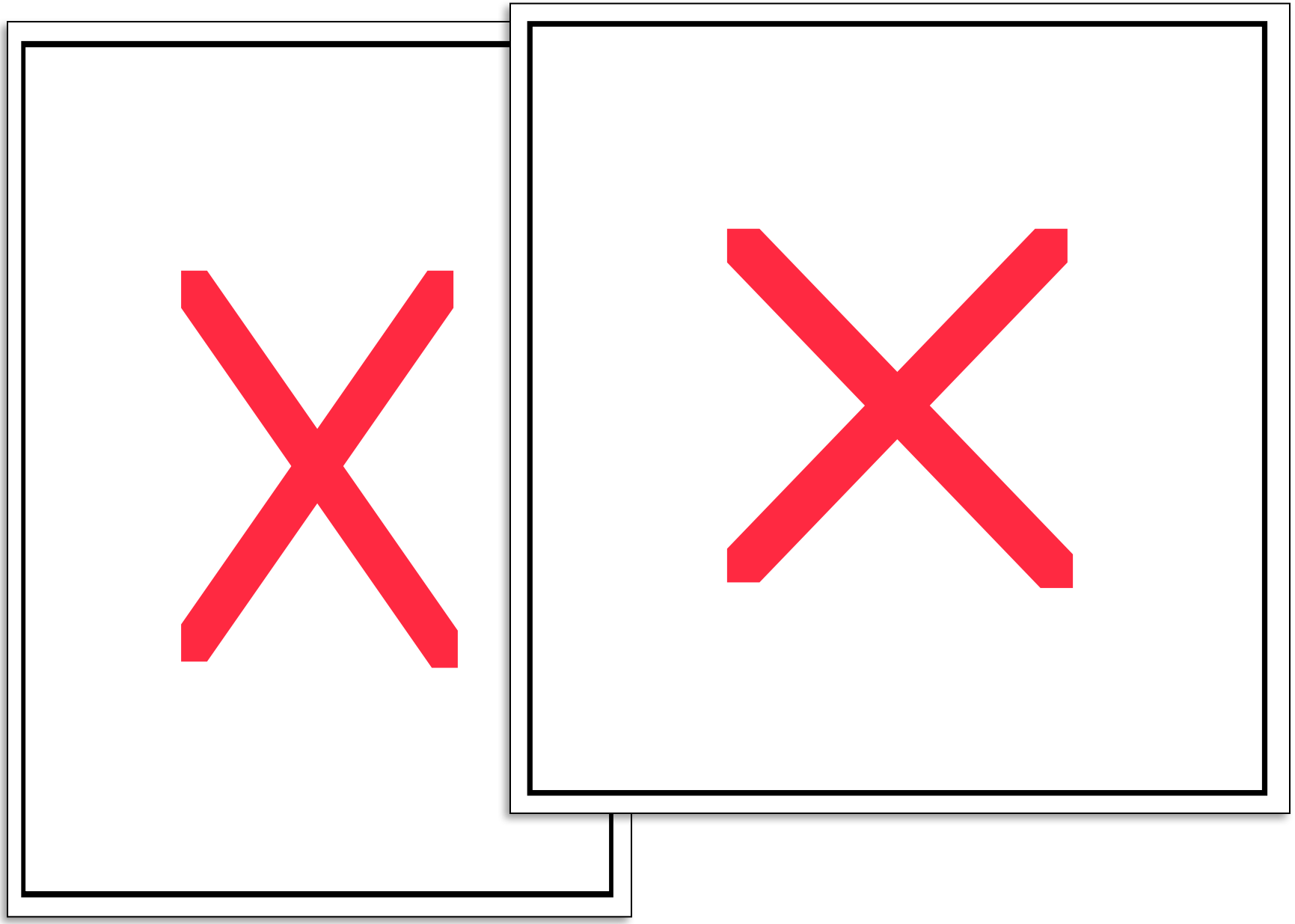
Product and Algorithm Description Document
standardized elements

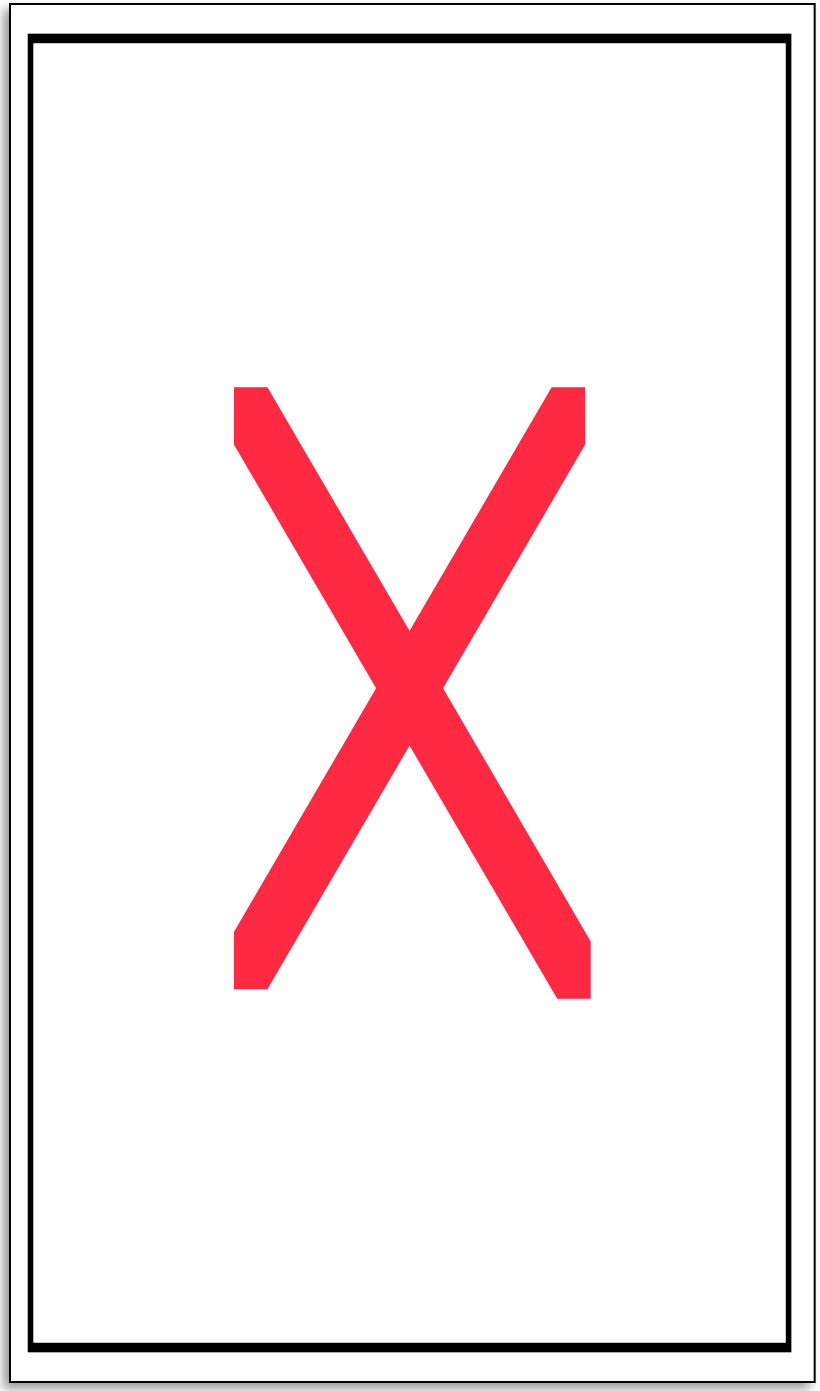
- Product Summary
  - defines what it is and what it's for
- Algorithm Description
  - as detailed as necessary to ensure full traceability to algorithm basis and heritage (e.g., links to published literature)
  - if applicable to multiple sensors, include any sensor-specific modifications required (e.g., adjustments for band passes)
  - algorithm failure conditions and associated product flags
- Implementation
  - how is the product distributed (product suite, file-types, encoding)
  - direct links to source code and/or software flow charts

Product and Algorithm Description Document
standardized elements

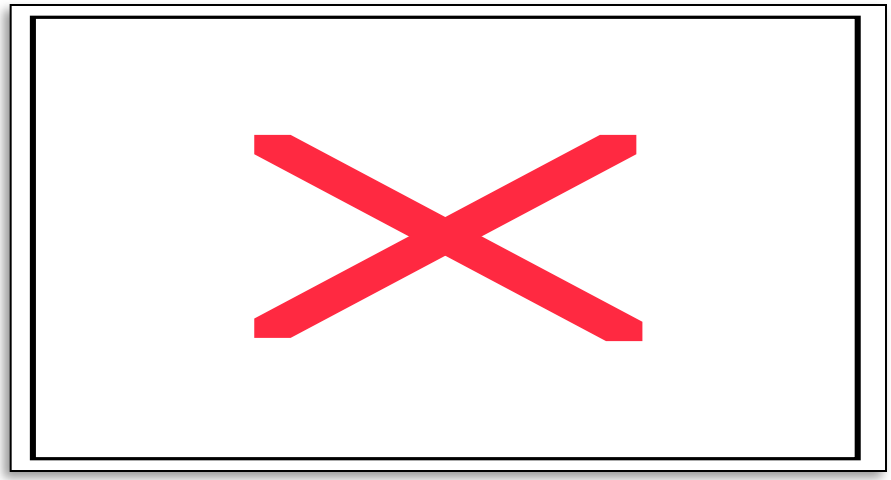
- Assessment
  - validation analyses (e.g., direct link to dynamic match-ups)
  - uncertainties
- References
  - links to previous ATBD(s) or TM(s), if relevant
  - links to published literature (DOIs)
- Product History
  - document version (date)
  - product change log

Product Description Documents

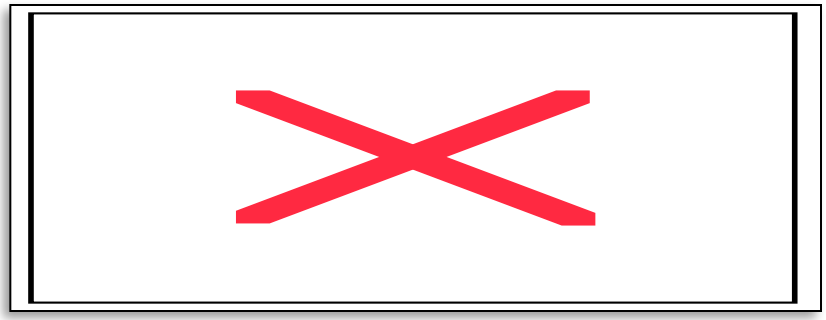


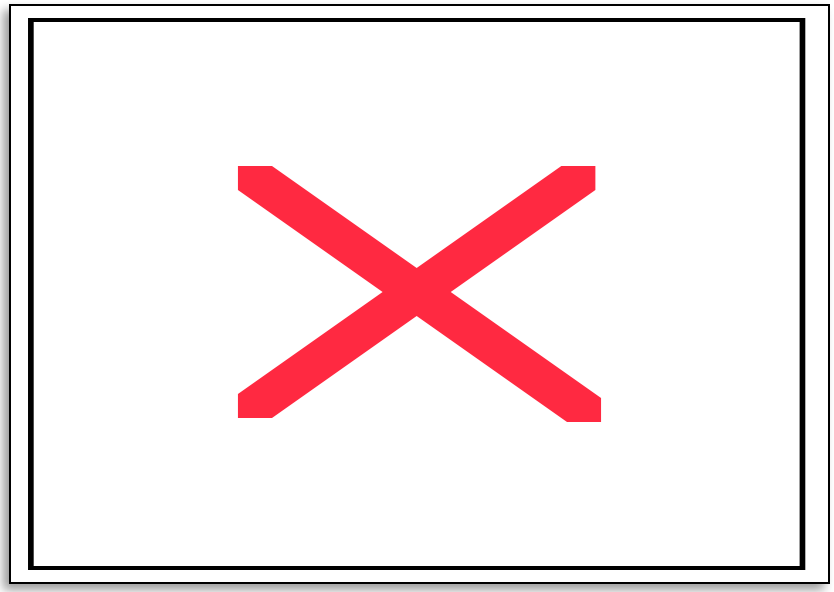


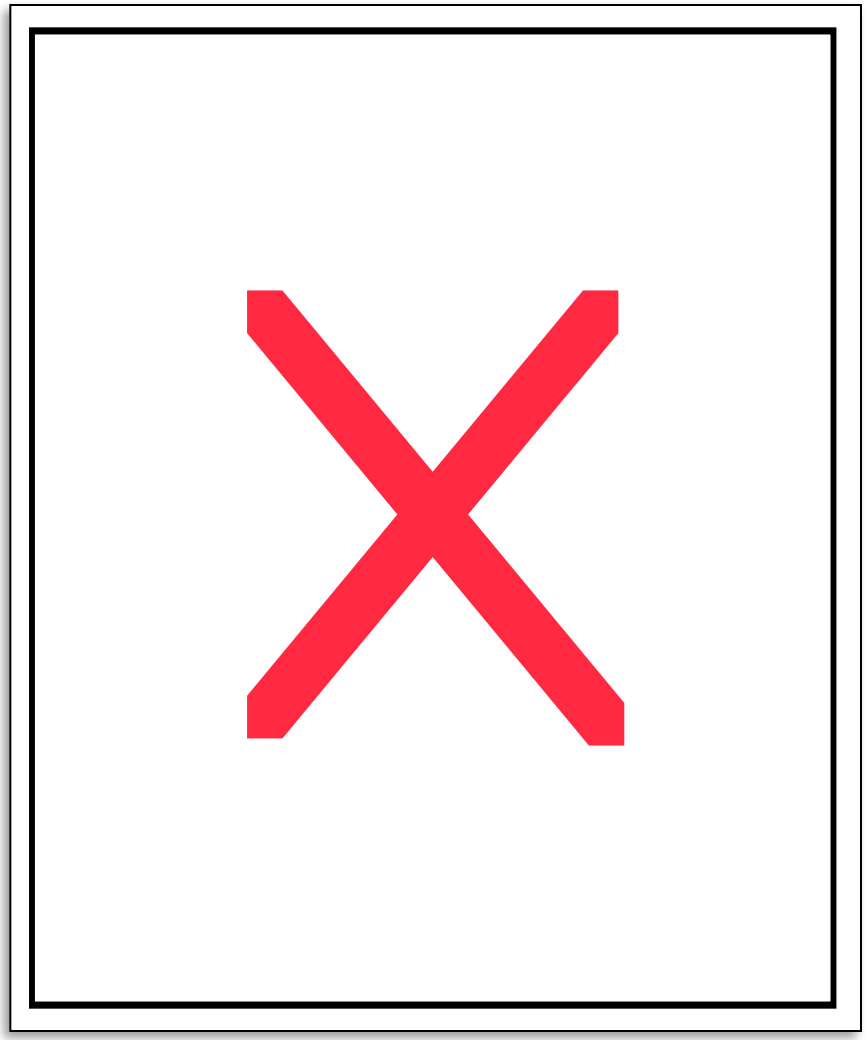
Algorithm Description



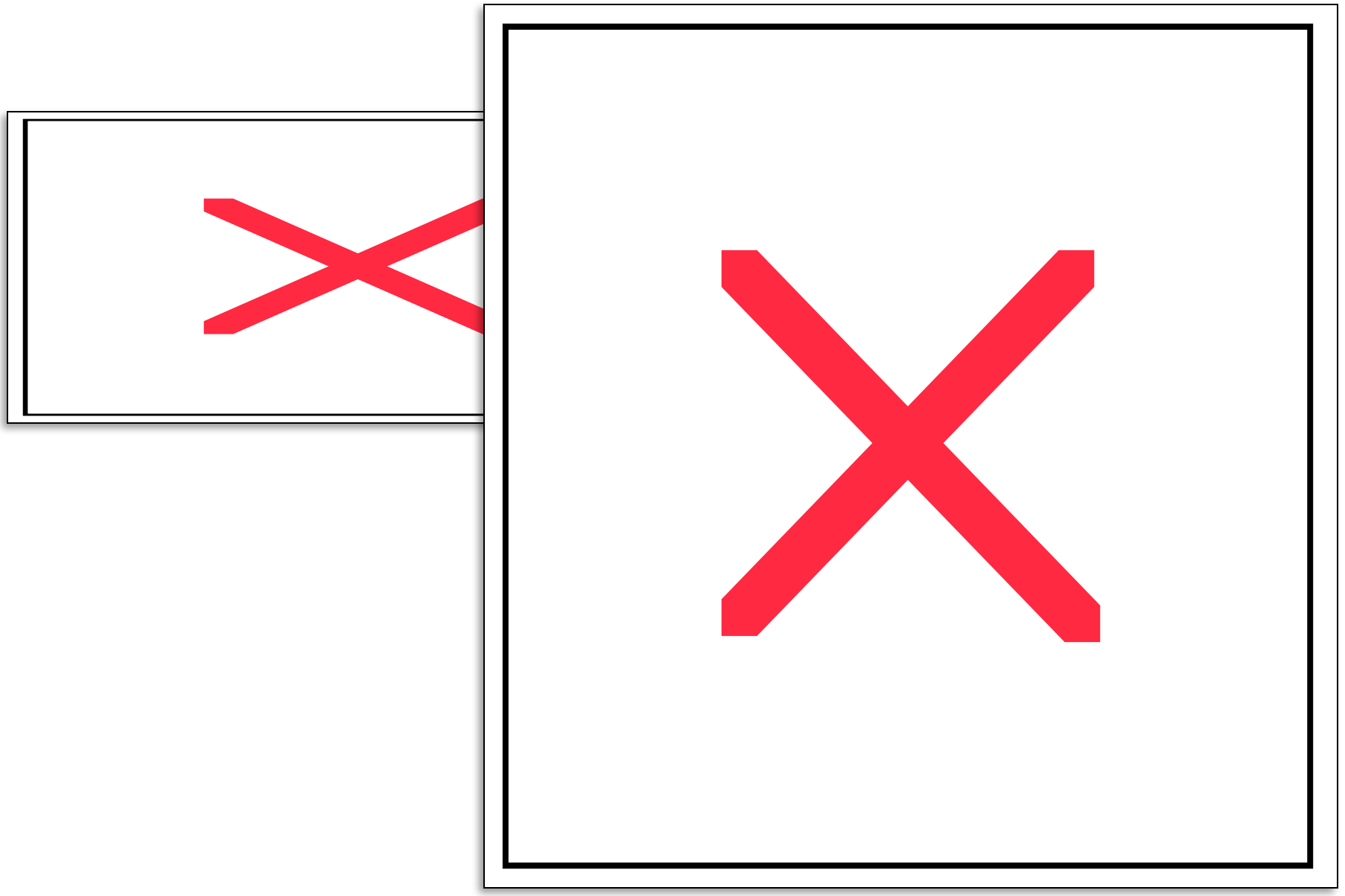
Implementation Details







Assessment



Product Lifecycle

from concept to standard product

1. PI develops new algorithm or modification, demonstrates feasibility, perhaps publishes results.
2. If PI and Ocean Team Leader agree, PI works with SIPS to implement in NASA processing code and to develop a test plan for verification and large-scale testing.
3. If PI is satisfied with implementation tests, and SIPS confirms that **required computing resources are available**, evaluation products and documentation will be produced and distributed, and the algorithm will be incorporated into SeaDAS.
   a. PI works with SIPS to develop or update the Product Description Document (to be hosted under “evaluation products”).
   b. SIPS/DAAC begins production and distribution of product
   c. PI performs assessment of results (validation, global dist., trends)
4. Before the next mission reprocessing opportunity, PI/SIPS/DAAC and Program Management review the performance evaluation, documentation, and appropriateness for standard production.

A.37 The Science of Terra, Aqua, and Suomi NPP

3.0. Instrument and Science Measurement Teams (encouraged not required)

- Additional detailed guidance for the Instrument and Science Measurement Teams are provided in the disciplinary Sections of 3.0 (3.1- 3.6).
- Proposed studies may be relevant to more than one team. Proposals should request membership on the team that, to the best of their knowledge, is most relevant to their research.
- Please see specific guidance in each section, and identify if the proposer called out membership in a particular science team
  - Land Measurements Team
  - Ocean Biology and Biogeochemistry Measurement Team (OCRT)
  - Cryospheric Sciences Measurement Team
  - Atmospheric Sciences Measurement Team
  - Biodiversity and Ecological Forecasting Team
  - Sea Surface Temperature Science Team

Move from Missions to Measurements due to Mission and Science Maturity

Discussion for Week/Break Outs

- Goal: Earth System Data Records - Continuity (MODIS to VIIRS2038)
  - Data product/algorithm identification, including gaps for each mission/sensor
  - SIPS resources needed, tied to Category 1 and Category 2 data products
- Continuity to JPSS – was in original solicitation and was tabled. SIPS have processing funds for EOS data product continuity as per the last SIPS meeting, but question is to whether the PIs could work assessment of JPSS-1 data products with small investment…
- SIPS were not included but if they were recompeted, and there was the opportunity for the competing institutions/SIPS to come in with an expansion of capability to support, say, non-NASA satellite data processing, would this be helpful or useful or not welcome at all?
- Reprocessing – "staged delivery"
- ATBD process, old, new, evolution of ideas? ATBD/Data Product Documentation and Reviews: Documentation on web sites lacking for Sensor/Team/ATBDs/Data – new (and existing?) users (especially in the applied/operational world) need to find the details
- Quantify instrument and measurement performance (e.g. calibration, stability)
  - MCST and VCST continuity
  - Need to be able to validate our space-based estimated Earth system properties
  - Acquired from multiple sensors / datasets - Aerosols, Clouds, Ocean Chemistry/Biology – PACE (and land capabilities?) + EV's and DS?

Discussion for Week/Break Outs

- Suomi NPP VIIRS – "assessments" of continuity data products (& new)
- Are all VIIRS created equal (MODIS-T v. MODIS-A) if continuity to JPSS
- Does VIIRS have the capability to produce all MODIS/EOS continuity data products?
  - If it does not, what is the solution?
  - If it does, then great, but there may be challenges to producing a given product (no PI to maintain/improve, time needed for assessment and continuity, etc.)
- Uncertainties associated with data products (more to come…)
- NOAA Data products – different? Better? Worse? Funding?
- Orphaned algorithms and other activities that were not recommended/proposed: Do we continue to produce these without an algorithm PI to manage?
  - For the products that we can attempt MODIS to VIIRS continuity, sounds as if many of these efforts are pushing ahead; however, quality assessments are underway in parallel, and it may be some time….
- Algorithm developers and validation investigators should continue to address important deficiencies in key data products (uncertainties
- Evolution to measurement teams and blend with MODIS-VIIRS Team (w/other mission teams)